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ABSTRACT

This is an in-depth course of study of the historical attempts to explain the evolutionary process and of recent developments pertinent to the study of biomedical evolution. Topics included in the module are: (1) ancient concepts of the evolutionary process; (2) various aspects of Lamarckism, Darwinism and neo-Darwinism, including substantiating arguments for Darwinism and opponents to Darwinism; (3) biochemical evolution, and (4) metaphysical considerations concerning aspects of evolutionary theory. The course is designed primarily for students interested in doing advanced work in biology or in biochemistry. The majority of the course was derived from "The Orion Book of Evolution" (Jean Rostand), "Space Life Sciences" (Cyril Ponnamperuma and Norman Gabel), and "The Science of Biology" (Paul Weisz). Thirteen performance objectives are cited. An extensive course outline is presented which includes the presentation of numerous theories related to evolutionary process. Audio-visual aids including films, transparencies, and equipment are suggested. A master sheet coordinates the entire curriculum event. (Author/EB)

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U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

THEORIES OF EVOLUTION

9315.42

SCIENCE

(Experimental)

SE 017 126

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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SCIENCE

(Experimental)

Written by Joseph P. Adams
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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THEORIES OF EVOLUTION

COURSE DESCRIPTION

This course is an in-depth study of the historical attempts to explain the evolutionary process and of recent developments pertinent to the study of biochemical evolution.

Topics to be studied include:

1. Ancient concepts of the evolutionary process.
2. Various aspects of Lamarckism, Darwinism and neo-Darwinism, including substantiating arguments for Darwinism, and opponents to Darwinism.
3. Modern hypotheses pertinent to biochemical evolution with substantiating evidence for these.
4. Metaphysical considerations concerning certain aspects of evolutionary theory.

ENROLLMENT GUIDELINES

Theories of Evolution is elective and designed primarily for those students who wish to do advanced work in biology or in biochemistry. The student should have successfully completed four quinmester courses of biology.

STATE ADOPTED TEXTBOOKS*

1. Biological Science Curriculum Study. Biological Science: Molecules to Man. 2nd ed. Boston: Houghton Mifflin, 1968.

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*Due to the fact that exhaustive studies of the topic of evolution at the high school level are not readily available, the majority of this course has been derived from the following three sources:

1. Ponnamperuma, Cyril and Gabel, Norman W. Current Status of Chemical Studies on the Origin of Life," Space Life Sciences. Dordrecht, Holland, D. Reidel Publishing Company, 1968. (pp. 64-96)

   (Reprints available from: Exobiology Division, Ames Research Center, NASA, Moffett Field, California, U.S.A.)

2. Rostand, Jean. The Orion Book of Evolution. New York: The Orion Press, 1961.

3. Weisz, Paul H. The Science of Biology. 3rd ed. New York: McGraw Hill, 1967.

PERFORMANCE OBJECTIVES

1. The student will state several reasons for the study of evolution.

2. The student will distinguish early concepts of spontaneous generation from those of evolution.

3. Given the names of various ancient Greek scholars, the student will identify the contribution of each to evolutionary thought.

4. The student will compare and contrast selected theories of evolution of the 16th and 17th century A.D.

5. Given a list of 18th and 19th century biologists, the student will discern Darwinian or Lamarckian ideas among them.

6. The student will cite the major concepts embodied in Darwin's theory of evolution.

7. The student will contrast Darwinism and Lamarckianism.

8. The student will discuss critically Darwin's theory.

9. By microscopic examination and a knowledge of living processes, the student will differentiate between coacervates and even the most primitive of living forms.

10. Given a set of equilibrium constants, the student will predict products favored in a set of reactions at equilibrium.

11. The student will generalize from data obtained with cultures, the distribution of microbes on earth today.

12. The student will discover the differential properties of microorganisms such as yeast, paramecium and amoeba.

13. The student will differentiate physical concepts from metaphysical concepts.

COURSE OUTLINE

I. Study of Evolution

A. Intellectual curiosity--man's eternal quest to explain the unknown

B. Integration of biological concepts--homology and analogy

C. Interpretation of extra-terrestrial phenomena--possible facilitation of interplanetary travel

II. Historical Theories Pertinent to Evolution

A. Early concepts of spontaneous generation

1. Nilsson--All organic beings originated from "germ" born of chemical elements (E p. 7)

2. Leduc--Primitive ovules the source of all creation (E p. 7)

B. History of the idea of evolution

1. Anaximander--611-546 B.C. (E p. 11, EGM pp. 3, 351)

a. First animals emerged from sea slime evaporated by sun's rays
b. Man's ancestor was an animal--certainly some kind of fish
c. Forbade his disciples to eat fish

2. Xenophanes--620-520 B.C. (E p. 12)

a. Thought animals and plants emerged from the earth
b. Foresaw the significance of fossils

3. Empodocles--circa 444 B.C. (E p. 12)

a. Theory of progress of life from imperfection to perfection
b. All irregular forms disappeared except those which responded to the law of inward harmony

4. Aristotle--384-322 B.C. (E p. 15)

a. Concept of organic affinity of organisms
b. Homology concept
c. Considered man in the animal kingdom grouped with the bipeds

NOTE: E represents The Orion Book of Evolution
EGM represents Evolution Genes and Man
HOL represents The History of Life

5. Greek antiquity to 17th century--no marked progress except that of Palissy who pointed out that shells were fossils deposited by primitive sea (E p. 15)

6. Benoit de Maillet--1656-1738 (E pp. 24-25)

   a. Wrote Telliamed in 1700's which contained meticulous description of bathysphere (unpublished until 1748)
   b. Believed earth covered by sea at one time
   c. Believed marine plants and trees encountering smoother slime and food "terrestrialized" themselves
   d. Believed walking, flying or creeping animals have their homolog in the sea
   e. Was ridiculed by Voltaire

7. Louis-Moreau de Maupertuis--1698-1759 (E p. 20, EGM p. 79)

   a. Formulated hypothesis of generalized transformism
   b. Believed human abnormalities and those of a variety of animals attributable to errors of arrangement during formation of foetus

8. Buffon--1753 (E pp. 19-20)

   a. Referred to divergence from a common stock as degeneration
   b. Thought climate, food and domestication could alter external form

9. Linnaeus, Charles--1707-1778 (E pp. 15-20)

   a. Established idea of specificity and of binomial nomenclature
   b. Did not believe in transformism
   c. Disquieted by certain facts pointed out by students rationalized that any "new" species must be "children of time"

10. Jean-Baptiste-Charles Robinet--1735-1820 (E pp. 30-31)

    a. Thought all organic beings are derived from a unique model or prototype
    b. Imagined he saw forms of various body parts in rocks, etc.

11. Diderot (E pp. 30-31)

    a. Progress of living things accomplished by the destruction of faulty combinations
    b. Believed that exercise, habit, necessity and action not only strengthen organs but also give rise to them

12. Dr. Erasmus Darwin (E pp. 35-36)

    a. Grandfather of Charles
    b. Wrote Zoonomia containing an unequivocal affirmation of progressive evolution of the organic world
    c. Believed all life arose from primordial filament having a creative "first cause"

13. Lamarck, Jean (E pp. 36-39, EGM pp. 13, 77, 79, 167, 181, 183, 224, 225, 240, 284, 358, 370)

    a. Formulated explicit, elaborated coherent theory of evolution in Philosophie Zoologique (1809)
    b. Assigned dual cause to evolutionary changes
        (1) A sort of innate tendency toward progress
        (2) The action of environmental circumstances
    c. Believed in the inheritance of acquired traits

14. Etienne Geoffrey Saint-Hilaire (E p. 39)

    a. Heir to Lamarckian thought
    b. Proclaimed mutability of species as did Lamarck, but conceived of it as sudden changes in the embryo
    c. Also attributed evolution to changes in the cosmic environment, alteration of the atmosphere through decreased O_2, increased CO_2
    d. Great idea dominating work is unity of structural plan

15. Cuvier (E p. 42)

    a. Violently opposed Geoffrey St. Hilaire
    b. Succeeded in reconstruction of entire skeletons of great extinct mammals
    c. Relied on the principle of correlation of forms
    d. Concluded that no connection or relationship existed between one fauna and the other
    e. Believed that the succession of forms was not caused by transformism, but rather by extinction, migrations, etc.

16. Robert Chambers--1844 (E p. 46)

    a. Wrote Vestiges of the Natural History of Creation
    b. Was severely judged by the "experts"
        (1) Heart of his thesis was criticized
        (2) Many inexactitudes in reasoning were turned up
    c. Proclaimed the universal evolution of the living world
    d. Believed that man was descended from a branch of apes which was outgrowth of batrachians

17. Goethe (E p. 45)

a. Was naturalist-poet
b. Expressed the idea of "metamorphosis of plants"
c. Recognized that the intermaxillary bone in the skull of man was also present in other mammals

18. Cournot and Renan--1851 (E pp. 49-50)

a. Were frankly transformist
b. Considered evolution a result of abnormal embryogeny or fruitful teratology

19. Charles Darwin--1809-1882 (E pp. 50-70, HOL pp. 24-27, EHM pp. 13, 23, 25, 77, 79, 82, 91, 108-113, 115, 117, 133, 165-167, 181-183, 188, 190, 192, 194, 215, 217, 227, 233, 236, 242, 250, 253, 277)

a. Enlightened by a voyage around the world which he took in his youth
b. Discovered that living species are variable
c. Could not accept the hypotheses of Lamarck which were also those of his grandfather
d. Reflected on the problem of evolution for 20 years
e. Wrote The Origin of Species which includes the following concepts:

(1) Spontaneous variability of the species
(2) Fundamental similarity between selective breeding and natural selection; the role of the breeder being performed by death in natural selection
(3) Overproduction of organisms according to the doctrine of Malthus
(4) Struggle for existence with other representatives of his species
(5) Families founded by those members having advantageous characteristics
(6) Advantageous characteristics increasing by degrees
(7) Species accordingly modified and better adapted to the conditions of his existence
(8) In summary, survival of the fittest or most adaptable by means of natural selection

f. Sexual selection also considered by Darwin to be an important factor in evolution

(1) Nuptial competition
(2) Ornamental displays
(3) Vocal qualities

20. Alfred Russell Wallace--1823-1913 (E pp. 53-54)

a. Arrived at same conclusions as Darwin
b. Sent Darwin a short essay of his manuscript in 1858 before the latter's conclusions had been published
c. The two authors had "gentlemen's agreement" before presentation to the Linnaean society

21. Chief scientific opponents of Darwinism (E p. 54)

a. L. Agassiz
b. Richard Owen

III. Evidence for the Validity of Darwin's Theory (E pp. 70-79)

A. Mutations (E p. 75, EOW pp. 55, 86, 87, 140, 251)

1. Some mutationists first believed that inherent variations are absolutely random

2. Mutationism and neo-Darwinism eventually led to recognize their complementarity

B. The birch tree moths and the industrial revolution--evidence for natural selection (EOL pp. 32-33)

C. Sexual selection--certain males among insects and birds rejected by females

D. Neoteinic mutations

1. Those which maintain certain juvenile or embryonic characters in the adult form of the offspring

2. The foregoing characterized by hexapod insects descended from myriapods which in larval state had 6 legs

E. Serological analogy between man and the great apes--the Rh factor

F. Cybernetics (E p. 79)

IV. Modern Hypotheses Pertinent to Biochemical Evolution

A. The Oparin-Haldane hypothesis

1. Accumulation of organic matter on primitive earth

2. The generation of replicating molecules

3. Substantiating evidence--experimental

   a. Miller and Urey's experiment (HOL p. 8)
   b. Fox's experiment on amino acid polymerization

4. Three stages of the evolutionary process

   a. Inorganic
   b. Organic
   c. Biological

B. Horowitz (1945)--First living entity a heterotroph which reproduced itself at the expense of prefabricated molecules

C. Kuiper (1953)--Primordial molecules would have been mixed with inorganic particles which could have acted as catalysts.

D. Burbridge and Burbridge (1958)--The evolutionary sequence presumably began with the origin of the universe and formation of the elements from the primordial cloud of hydrogen gas

E. Lederberg and Cowie (1958); Fowler et al. (1961)--Chemical evolution should take into account the very early periods of the universe

F. Equilibrium constants for reactions to produce gases thought to be present in the primitive atmosphere

G. Latimer (1950)

   1. Possibility of nitrides and carbides in the earth's mantle

   2. Reaction of nitrides and carbides with water can produce free nitrogen and hydrocarbons respectively

H. Rutten (1962)

   1. Claims difference between primeval anoxygenic and present oxygenic atmosphere is as clear cut as day and night

   2. Statement based on several comparisons between ancient and modern sediments

I. Rankama (1955)--Determined ratio of ferrous to ferric iron in ancient and recent sediments

J. Lepp and Goldich (1959)

   1. Studied pre-Cambrian and later times

   2. Investigations indicate pre-Cambrian formations siliceous; in later formations iron and silica are separate indicating increased oxygen

K. Berkner and Marshall (1956)

1. Developed convincing arguments to show that oxygen accumulated as a result of photosynthesis

2. Maintain that the sudden proliferation of life in the Cambrian era due to the attainment of the Pasteur point; namely, a concentration of about 1% of the present oxygen pressure

3. Consider oxygen to be derived from 2 sources

    a. Plant photosynthesis
    b. Photodissociation of water by short wavelength ultraviolet in the upper atmosphere

4. Predominance of aerobic over anerobic life forms

L. Sources of energy available for the synthesis of organic compounds

1. Ultraviolet light

2. Electric discharge

3. Radioactivity

4. Volcanoes

5. Solar flux, other than UV

6. Shock waves produced by meteorites traversing primitive atmosphere

M. The synthesis of amino acids

1. The spark discharge apparatus of Miller and Urey

2. HCN as a key intermediate for producing amino acids

    a. Glycine
    b. Serine
    c. Alanine
    d. Aspartic acid

N. Ponnamperuma, et al. (1965-1967)

1. Over 95% of methane converted to other organic compounds

2. HCN accounted for 18% of the product

3. Obtained a whole range of amino acids using N-acetylglycine as a starting material and exposing to gamma radiation

O. Oro (1960)

1. First synthesis of purines under simulated earth conditions

2. Demonstrated adenine synthesis from a concentrated solution of ammonium cyanide

P. Sanchez, et al. (1966)--Obtained cytosine from cyanoacetylene and urea

Q. Synthesis of monosaccharides

1. By polymerization of formaldehyde

2. Ribose and deoxyribose by UV irradiation of formaldehyde

R. Ponnamperuma, et al. (1963)--Nucleosides and nucleotides

1. Synthesis of adenosine from ribose, adenine and phosphate in UV light

2. Deoxyadenosine in 1% yield from cyanide, adenine and deoxyribose

S. Waenheldt and Fox (1967)--Phosphorylation of nucleosides

1. Adenosine

2. Cytidine

3. Guanosine

4. Uridine

5. Deoxycytidine

6. Thymidine

T. Other biochemical substances recently synthesized abiotically

1. Fatty acids

2. Porphyrins

3. Polypeptides

4. Nucleic acids

5. Coacervates

U. Future abiotic synthesis

1. Polynucleotides - replicating systems

2. Organelles

3. Living cells

V. Studies of Evolution--Heresy or Divine Plan?

A. The Scopes trial

B. Metaphysical considerations

1. The semantics of the term "creation"

a. Production of something from nothing
b. Reorganization of pre-existing material

2. Other considerations

a. Creation itself as a refutation of the first law of thermodynamics
b. Spontaneous change from a disordered to a highly ordered system as refutation of the second law of thermodynamics
c. Infinity and eternity

EXPERIMENTS

Biological Science Curriculum Study. Biological Science: Molecules to Man. Rev. ed. Boston: Houghton Mifflin Co., 1968.

1. Investigating Sources of Bacterial Growth (Exp. 4-6, pp. 94-95)
2. Formation of Coacervates (Exp. 5-14, pp. 132-133)
3. Investigating the Effects of Mutants in Bacteria (Exp. 10-9, pp. 244-245)

Dade County Curriculum Bulletin. Advanced Biology Course of Study and Laboratory Guide. Miami, Florida: Dade County Public Schools, 1966.

4. Reversibility of Enzymes (pp. 96-98)
5. Observation of Mitochondria (p. 107)
6. Neurospora--Crossing Strains (pp. 115-119)

Space Resources for Teachers: Biology. A Curriculum Project Prepared by the University of California, Lawrence Hall of Science, Berkeley, California, Harvey E. White, Director. NASA, Washington, D. C. 20546, January 1969, $2.75.

7. Survival of Earth Microbes in a Simulated Martian Environment (p. 167)
8. The Nature of Fluorescence in Various Earth Microbes (p. 168)
9. Earth Origin Microorganisms and the Contamination of the Moon or of Planets (p. 175)

DEMONSTRATIONS

Experiments in Nuclear Science. Chase, Grafton D.; Rituper, Stephen; and Sulcoski, John W. Burgess Publishing Company, Minneapolis, Minn., 6th printing, 1968.

1. Half-Life of a Radioisotope (Exp. 20, p. 48)
2. Non-Root Feeding of Plants (Exp. 28, p. 76)
3. Fallout (Exp. 39, p. 107)

Space Science: A Guide Outlining Understandings, Fundamental Concepts, and Activities. Developed at Columbia University in cooperation with the Goddard Institute for Space Studies, NASA, Washington, D. C., 1969.

4. Assembly of a DNA Molecule (p. 111)
5. Confirming the Possibility that Life Arrived on Earth from Outer Space (p. 109)

RELATED PROBLEMS AND STUDENT PROJECTS

1. Did vertebrates arise from the echinoderms, the annelids or the arthropods?

2. What are some factors which may cause extinction of a species?

3. How can one visualize terrestrial environments minus their organic populations?

4. How can one account for the discovery of volcanic rock 30,000,000 years old in a well drilled 6000 feet deep in a Pacific atoll?

5. Why is so little of the early Mesozoic record preserved?

SPECIAL EQUIPMENT

1. Geiger counter
2. Microscope with oil immersion objective
3. Fossilized rocks
4. Representative rock types
5. Pure culture of Bacillus cereus
6. Antibiotic disks (Penicillin and aureomycin)
7. Ultraviolet light source
8. Samples of radioactive minerals

TEXTS

1. Biological Sciences Curriculum Study. Biological Science: Molecules to Man. Boston: Houghton Mifflin Co., 1968.

2. Dickerson, Richard E. and Geis, Irving. The Structure and Action of Proteins. New York: Harper and Row, 1969. Chapter 5.

3. Fox, Sidney W. and Foster, Joseph F. Introduction to Protein Chemistry. New York: Wiley and Sons, 1957. pp. 429-439.

4. Dobzhansky, Theodosius. Evolution, Genes and Man. New York: Wiley and Sons, 1955.

5. McAlister, A. Lee. The History of Life. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1968.

6. Ponnamperuma, Cyril and Gobel, Norman W. "Current Status of Chemical Studies on the Origin of Life," Space Life Science. Dordracht-Holland: D. Reidel Publishing Co., 1968. (Reprints available)

7. Rostand, Jean. The Orion Book of Evolution. New York: The Orion Press, 1961. (English translation)

8. Weisz, Paul H. The Science of Biology. New York: McGraw-Hill, 1967.

PLACES TO VISIT

1. Crandon Park Zoo - Animal evolution
2. Fairchild Garden - Plant evolution
3. Museum of Natural Science
4. University of Miami, Molecular Biology Department

READING LISTS

1. Abelson, P. H. "Organic Constituents of Fossils," in Carnegie Institution of Washington Yearbook. Washington, D. C.: Carnegie Institute, 1953-54. No. 53, pp. 97-101.

2. Abelson, P. H. "Chemical Events on the Primitive Earth," National Academy of Science. U. S. 55 1365-72. 1966.

3. Ageno, M. "Does Quantum Mechanics Exclude Life?" Nature. London: 205, 1306-07. 1965.

4. Anfinsen, C. B. Molecular Basis of Evolution. New York: Wiley, 1959.

5. Bahadur, K. "The Reactions Involved in the Formation of Compounds Preliminary to the Synthesis of Protoplasm and Other Materials of Biological Importance," in The Origin of Life on the Earth. Oxford: Pergamon Press, pp. 140-150. First International Symposium, Moscow, August 19-24, 1957. (English translation)

6. Bahadur, K.; Galand, D.; and Smith, A. "The Inevitable Appearance of Protocells on the Primitive Earth," Spaceflight II. London: 325, September, 1969.

7. Baldwin, E. "Biochemistry and Evolution," in The Nature of Biological Diversity. New York: McGraw Hill, 1963. pp. 45-68.

8. Bastian, H. C. Nature and Origin of Living Matter. Philadelphia: Lippincott, 1905.

9. Bernal, J. D. "Biochemical Evolution," in Horizons in Biochemistry. New York: Academic Press, 1962. pp. 11-22.

10. Bernal, J. D. "Thermodynamics and Kinetics of Spontaneous Generation." Nature. London: May 28, 1960. pp. 693-95.

11. Beutner, R. Life's Beginning on Earth. Baltimore: Williams and Wilkins, 1938.

12. Blum, H. F. Time's Arrow and Evolution. Princeton, N. J.: Princeton University Press, 1951.

13. Blum, J. F. "A Consideration of Evolution from a Thermodynamic Viewpoint," American Nature. Chicago: 1935. pp. 354-369.

14. Briggs, M. H. "Dating the Origin of Life on Earth," Evolution. Lawrence, Kansas: September, 1959. pp. 416-18.

15. Oro, J. and Skewes, H. B. "Free Amino-Acids on Human Fingers. The Question of Contamination in Microanalysis," Nature. London: 207, September 4, 1965. pp. 1042-45.

16. Ponnamperuma, C. "Chemical Evolution and the Origin of Life," in Extraterrestrial Biophysics, Biology, and Space Medicine. Frankfurt, West Germany: University Press, 1968. pp. 183-195.

17. Ponnamperuma, C. "Ultraviolet Radiation and the Origin of Life," in Photophysiology, Vol. III. New York: Academic Press, 1968. pp. 253-267.

18. Wigner, E. P. "The Probability of the Existence of a Self-Producing Unit," in Logic of Personal Knowledge. Glencoe, Ill.: Free Press, 1961. pp. 231-238.

DADE COUNTY FILMS

1. Carbon Fourteen
AV#1-01926, 12 min., BW

2. In the Beginning
AV#1-30356, 28 min., C

3. Cosmic Rays
AV#1-30330, 29 min., C

4. Evidence for the Ice Age
AV#1-10969, 19 min., C

5. Heredity Basis of Evolution
AV#1-30602, 28 min., C

6. How Living Things Change
AV#1-02221, 11 min., C

7. Marine Animals of the Open Coast
AV#1-11075, 22 min., C

8. Rocks and the Record
AV#1-30349, 28 min., C

9. Darwin and Evolution
AV#1-30553, 28 min., C

10. Darrow, Clarence
AV#1-31562, 26 min., BW

DADE COUNTY TRANSPARENCIES

1.	Evolution of North America	"The Geologic Time Scale"	#2-00314
2.	Evolution of North America	"The Key to Rock Types"	#2-00315

MASTER SHEET--THEORIES OF EVOLUTION

Objectives	Laboratory Experiments	Student Text (The Green Book of Evolution)	Supplementary Reference Texts	Films	Transparencies	Demonstrations
1			#6. pp. 64-65	3,5		1,3,5
2	1	#2. pp. 7,11	#6. p. 231	2,8		
3		#2. pp. 11-15				
4		#2. pp. 15-25	#6. p. 79	6		
5		#2. pp. 25-39	#6. pp. 13,77, 79			
6		#2. pp. 50-70	#3. pp. 24-27 #6. pp. 13 21,25, 71,79,82,91	1	1	
7			#6. pp. 167,181, 183,224,215, 240,284,158, 370	4		
8		#2. pp. 50-70	#6. pp. 188-194, 215-230,250-277	7	2	2
9	2		#1. pp. 132-133 #6. p. 111			4
10	3		#1. p. 9 Dade County Curriculum Bulletin, Advanced Biology Course of Study and Laboratory Guide. pp. 96-98			
11	4,5,6		#6. p. 66			
12	7,8		Dade County Curriculum Bulletin, Advanced Biology Course of Study and Laboratory Guide. pp. 107, 115,119			
13				9,10		